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TI     Tin alloys for lead-free cast balancing weights on automotive wheels
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AB     The wheel-balancing wts. free of Pb are manufd. from the Sn alloys having
       the upper melting temp. <320.degree., and the Vickers microhardness
       .gtoreq.6 (esp. 9-35).  The Sn alloys nominally contain Cu 0.01-10, Sb
       0.01-20, Bi 0.01-65, Ag 0.01-20, Zn 0.01-30, P 0.001-2, and/or In
       0.01-15%.  The Sn-alloy block parts are typically manufd. by pressure
       casting in permanent molds, and can be equipped with a steel clip for
       attachment to an automotive wheel rim in spin balancing.  The clip-on wt.
       parts are preferably cast from the Sn alloy contg. 0.5-4% Cu and
       optionally 0.5-10% Sb.  The Sn-2 Cu-6% Sb alloy has the melting range of
       235-270.degree. and the initial microhardness of 23.1, vs. 270-310.degree.
       for the Pb-3% Sb alloy with the aged microhardness of 13.
RE.CNT  5       THERE ARE 5 CITED REFERENCES AVAILABLE FOR THIS RECORD
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(54) Title: TIN ALLOY WHEEL BALANCING WEIGHTS

(57) Abstract

A wheel weight suitable for balancing the wheels of automobiles which comprises an alloy of tin having a melting range with an upper limit of below approximately 320 °C and a hardness of at least approximately 6Hv.

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TIN ALLOY WHEEL BALANCING WEIGHTS

The present invention relates to the manufacture of weights which are used to balance the wheels of automobiles, including both cars and lorries. In particular it relates to the manufacture of weights suitable to replace those used at present which are made of lead.

It will be appreciated that there is a growing pressure on lead use worldwide and, in particular, lead in automobile components is coming under scrutiny. Environmental Agencies and legislators have identified a potential hazard, principally from disposal regimes. End-of-life procedures for the disposal of lead are now being examined and reductions in the use of lead have been called for. Car manufacturers are responding and looking for means to reduce the lead content of vehicles.

Lead wheel weights represent an obvious lead source, up to 500g may be used to balance the wheels of cars, whilst larger vehicles may use up to 500g for each individual weight.

These lead weights are often coated or plated to achieve a bright or more metallic finish that better matches the appearance of alloy wheels. Such surface treatments may also be used to retard the blackening of the weight on ageing, again for aesthetic reasons. Previously, lead weights have been coated with a polymer by powder coating. This is done for a number of reasons:

(i) to prevent corrosion reactions between the steel clip and aluminium alloy wheels,

(ii) to give a better surface finish, and

(iii) to present a more environmentally friendly image by encapsulating the lead.

However, the lead is still present and gives rise to disposal problems. Furthermore, recycling is more difficult because extra health and safety controls must be observed upon disposal of the polymer coating.

Zinc has been trialed in the industry but is not preferred due to a number of factors:

(i) the melting point is high (419°C) compared to that of lead (327°C) requiring upgrading of production equipment and the use of additional energy,

(ii) contamination of lead with zinc can lead to corrosion concerns,

(iii) the hardness of zinc makes deformation during fitting to the wheel difficult and this makes its application to the wheel hazardous,

(iv) zinc is sometimes classed as a metal "dangerous to the environment" and therefore does not offer a significant advantage over lead,

(v) zinc corrodes easily and therefore needs to be coated, and

(vi) zinc is more difficult to cut and deform to provide the correct size and shape.

Steel has also been trialed for the production of wheel weights but also suffers from a number of disadvantages:

(i) steel corrodes easily and therefore needs to be coated,

(ii) the hardness of steel makes deformation during fitting to the wheel difficult and this makes its application to the wheel hazardous,

(iii) steel is more difficult to cut and deform to provide the correct size and shape,

(iv) its use requires upgrading of production

apparatus, and

(v) it is difficult to cast with a clip for attachment to the wheel.

Polymers have also been trialed but also suffer from a number of disadvantages:

(i) they are not sufficiently dense,

(ii) they are difficult to cast with a clip for attachment to the wheel, and

(iii) they require different production apparatus.

Pure tin has also been trialed for the production of wheel weights. However, although the weights produced performed in a manner similar to the standard lead weights, pure tin was found to be unsuitable for the mass production of cast weights. As a pure metal, tin has a single melting point rather than a melting or pasty range which is characteristic of alloys. This narrow solidification range caused problems during production as precise control of the bath and injection nozzle temperatures was required to achieve acceptable results. The fluidity of molten tin also causes problems, particularly flashing around mould lines.

Another proposal for solving the problem of balancing wheels is based on injecting a polymer or placing polymer composite spheres into the airspace of a tyre in such a way that the imbalance is countered dynamically as the vehicle is driven. However, there are a number of disadvantages associated with this method. The treatment must be continuously applied to match tyre wear and the resultant coating may interfere with tyre repair and invalidate tyre warranties. The materials used are dessicated to avoid rust enhancement problems but this makes them water intolerant. Consequently, dehumidified air must be

used when inflating the tyres and watery lube mounting materials must be avoided. The grains may also jam valve cores and specialist tools are required for applying the material.

Another method for balancing tyres uses balancing rings or "hula hoops" bolted securely to the wheel. They are made of steel or aluminium and are filled with either steel shot or mercury. However, due to its toxicity, the use of mercury is also a potential environmental hazard and may be banned in future.

It is an object of the present invention to provide wheel weights which exhibit performance characteristics similar to or better than lead wheel weights known in the art whilst avoiding the environmental problems associated therewith.

The present invention accordingly provides a wheel weight which comprises an alloy of tin having a melting range with an upper limit of below approximately 320°C and a hardness of at least approximately 6Hv.

The unit Hv represents the hardness value obtained by a Vickers hardness measurement of resistance to plastic deformation. The load applied in this case is 0.5kg and the size of the indentation is related to the hardness by using standard tables.

Two kinds of wheel weight design are currently in use, they are:

(i) "clip-on" weights, comprising a cast block with a clip, preferably made of steel, which may be either integral to the casting or removably attached thereto which enables the weight to be clamped onto the exterior wheel rim, and

(ii) "adhesive" weights, comprising a mechanically formed block with underside adhesive which enables the weight to be attached inside the wheel.

Preferably, the tin alloy used for the clip-on weights has a hardness value in the range of from 9 to 35 Hv, more preferably 12 to 35Hv. In this case a greater hardness is required to limit deformation or damage during fitting. However, some deformation may be required on occasions when an exact fit cannot be achieved therefore the alloy should not be excessively hard, that is not more than 35Hv.

Preferably, for the adhesive weights the tin alloy used has a hardness value in the range of from 6 to 25Hv. In this case a lower hardness value is preferable because these weights have to be bent around the wheel interior upon application by a mechanic.

In both clip-on weights and adhesive weights the use of such tin alloys to balance wheels gives a number of advantages:

(i) it minimizes the use of toxic or hazardous materials such as lead and mercury,

(ii) alloying broadens the melting point of pure tin to give a melting or pasty range and also reduces the fluidity of the molten metal, these changes in physical properties overcome production problems associated with the use of pure tin,

(iii) high tin alloys are easier to plate with a bright finish such as chromium, if required, than alloys containing lead,

(iv) wheel weights can be manufactured from these tin alloys using the same production apparatus used for lead, therefore minimal modification of

plants is required,

(v) the alloys are corrosion resistant,

(vi) the alloys match the physical properties of lead with regard to hardness, deformation and cutability,

(vii) the alloys have a preferable appearance and can be polished to a bright colour,

(viii) the alloys can be made to be more resistant to impact than lead therefore reducing damage to the weights on application to the wheel and on impact with, for example, a kerb,

(ix) the alloys are typically cast at a lower temperature therefore reducing energyrequirements, and

(x) the alloys have a higher scrap value than lead, which encourages recycling and will help to fulfill the aims of the proposed European Union End-Of-Life Vehicle legislation. Tin alloys have an advantage over proposals based on polymers or polymer composites in this respect as the latter are more difficult or impossible to recycle and they also limit tyre repair.

In the clip-on weights tin alloys can also be made to exhibit greater stiffness than lead producing better adhesion to the clip and the wheel. This also limits deformation or damage during fitting.

The melting point of tin is lower than that of lead or zinc, this is advantageous because the energy requirements for production of the weights are reduced. An extra advantage of the lower casting temperature is that the lifetime of the casting moulds is increased. Furthermore, the softness of the mechanically formed tin product, compared to alternatives such as zinc, allows easy separation of each weight by cutting.

The selection of the optimum tin alloy allows the manufacture of weights having the correct physical properties, improved corrosion resistance, suitable melting or mechanical working performance (depending on the production method) and the use of the existing weights designs.

Copper can be added to tin to increase hardness and therefore deformation resistance, as well as providing an alloy which, when molten, is suitable for rapid cycle die casting. A tin alloy comprising about 3wt% copper can be used to match the hardness of the current lead product while keeping the melting temperature below 320°C. A hardness of around 13 Hv is currently used for weights to be attached on the outer rim of a wheel. A softer alloy is required for the self-adhesive wheel weights to allow a certain degree of bending on application to the wheel and for the purposes of mechanical forming. An alloy comprising about 1wt% copper is recommended for this application.

Antimony can also be added as an alloying element to tin to increase its hardness. In this case it is possible to increase the hardness to a greater extent than with copper but with less effect on the melting temperature. A limited pasty range, which is often required for die casting, can be achieved in tin alloys comprising up to approximately 15wt%, preferably approximately 10wt% antimony. Once again a softer alloy is recommended for the self-adhesive weights which would be of a lower antimony content.

The individual effect on hardness of both copper and antimony is greater than the increase in hardness achieved if the two alloying elements are combined. This allows higher percentages of these elements to be added in combination, and thus a greater adjustment of

melting temperature to be achieved, without the alloy becoming excessively hard.

Bismuth can be used to increase the density of the alloy and improve the efficiency of the weight for wheel balancing. Unlike the other alloy additions, high bismuth contents can be used without increasing the melting temperature. However, high bismuth contents can also deleteriously effect the mechanical properties of tin, i.e. make the metal brittle, and such alloys are therefore less suited to the production of self-adhesive weights where significant mechanical deformation occurs during manufacture. Tin alloys containing from 0.1 to 10wt% of bismuth can be used which provide an increased density but maintain satisfactory ductility. Suitable hardness can also be achieved.

Other elements can also be used to increase the hardness of the tin alloy to a required level, such as silver, zinc and phosphorus. Other elements such as indium may also be added. This gives an advantage in that it helps the alloy to achieve wetting of the clip in the cast product.

Mixtures of the above elements may be used to achieve the required physical and mechanical properties for production purposes, as well as a suitable hardness and stiffness to ensure reliable long term fixation to the wheel.

Accordingly, the tin alloy utilised in the present invention has a melting range with an upper limit of below approximately 320°C and a hardness of at least approximately 6Hv and may comprise copper in an amount of from 0.01 to 10wt%, and/or antimony in an amount of from 0.01 to 20wt%, and/or bismuth in an amount of

from 0.01 to 65wt%, and/or silver in an amount of from 0.01 to 20wt%, and/or zinc in an amount of from 0.01 to 30wt%, and/or phosphorus in an amount of from 0.001 to 2wt%, and/or indium in an amount of from 0.01 to 15wt%, with a balance of tin.

Preferably, the tin alloy comprises copper in an amount of from 0.05 to 8wt%, and/or antimony in an amount of from 0.05 to 15wt%, and/or bismuth in an amount of from 0.05 to 20wt%, and/or silver in an amount of from 0.05 to 10wt%, and/or zinc in an amount of from 0.05 to 20wt%, and/or phosphorus in an amount of from 0.001 to 0.5wt%, and/or indium in an amount of from 0.05 to 10wt%, with a balance of tin.

More preferably, the tin alloy comprises copper in an amount of from 0.1 to 5wt%, and/or antimony in an amount of from 0.1 to 12wt%, and/or bismuth in an amount of from 0.1 to 10wt%, and/or silver in an amount of from 0.1 to 7wt%, and/or zinc in an amount of from 0.1 to 15wt%, and/or phosphorus in an amount of from 0.001 to 0.1wt%, and/or indium in an amount of from 0.1 to 5wt%, with a balance of tin.

Even more preferably, the tin alloy comprises copper in an amount of from 0.15 to 4 wt% and/or antimony in an amount of from 0.5 to 10wt%, and/or bismuth in an amount of from 0.5 to 8wt%, and/or silver in an amount of from 0.5 to 5wt%, and/or zinc in an amount of from 0.5 to 10wt%, and/or phosphorus in an amount of from 0.01 to 0.08wt%, and/or indium in an amount of from 0.5 to 3wt%, with a balance of tin.

It will be appreciated that the "balance of tin" will consist essentially of tin together with unavoidable impurities. Such impurities will generally not comprise more than 0.5 wt%. In general the tin will be

present in an amount of from 35 to 99.999 wt%, preferably from 80 to 99.999 wt%, more preferably from 85 to 99.999 wt% and even more preferably from 90 to 99.99 wt%.

A particularly preferred alloy for clip-on weights comprises copper in an amount of from 0.5 to 4 wt%, more preferably from 1.25 to 1.5 wt%, and tin in an amount of from 96 to 99.5 wt%, more preferably from 98.75 to 98.5 wt%. Another particularly preferred alloy for clip-on weights comprises copper in an amount of from 0.5 to 4 wt%, more preferably from 0.5 to 1.25 wt% and antimony in an amount of from 0.5 to 10 wt%, more preferably from 6 to 7.5 wt%, and tin in an amount of from 86 to 99 wt%, more preferably from 91.25 to 93.5 wt%.

A particularly preferred alloy for adhesive weights comprises copper in an amount of from 0.05 to 4 wt% more preferably approximately 1.5 wt% and tin in an amount of from 96 to 99.95 wt%, more preferably approximately 98.5 wt%. Another particularly preferred alloy for adhesive weights comprises antimony in an amount of from 0.5 to 10 wt% and tin in an amount of from 90 to 99.5 wt%. Another particularly preferred alloy for adhesive weights comprises antimony in an amount of from 0.5 to 10 wt% and copper in an amount of from 0.05 to 4 wt% and tin in an amount of from 86 to 99.45 wt%.

It is possible that the wheel weight of the present invention may be subjected to further treatments or coatings. This may be to provide corrosion resistance and/or an aesthetically pleasing finish. In the case of clip-on weights such a coating may be applied to the tin alloy block forming the main body of the weight, or to the clip, or to both the block and the

clip. One possibility is a polymer coating produced by the method of powder coating. This is a standard industrial method and it involves applying polymer resin particles to the surface with a special gun which imparts an electrostatic charge to the particles. The powder coating is then treated, often by heating, so that the particles crosslink or fuse to form the polymer layer. Another possibility is chromium plating using standard electroplating techniques such as rack-and-barrel plating. Another possibility is zinc plating.

Preferably, the present invention provides for a wheel weight which comprises an alloy of tin as hereinbefore described which has a melting or pasty range of from 5 to 50°C, more preferably from 10 to 50°C, even more preferably from 14 to 40°C. That is, the temperature at which melting of the alloy begins and the temperature at which melting of the alloy is complete are separated by from 5 to 50°C, more preferably from 10 to 50°C, even more preferably from 14 to 40°C. As mentioned earlier in the description, the production of cast weights is simplified when the metal used does not have a narrow solidification range because this does not require such rigorous control of bath and injection nozzle temperatures in order to achieve acceptable results.

The present invention also encompasses a wheel assembly for an automobile, including both cars and lorries, which comprises one or more wheel weights as hereinbefore described.

In another aspect, the present invention provides a process of forming a wheel weight comprising the steps of:

(i) melting a portion of tin,

(ii) adding the required amounts of the elements to be alloyed to the molten tin,

(iii) allowing the melt to stand so that alloying can take place, the time period for this step being dependent upon the temperature,

(iv) casting the alloy by transferring the melt into a mould and either

(v) remelting and die-casting the alloy, or

(vi) extruding the alloy into a wire, stamping it to form the required shape and coating it on one side with adhesive tape.

Preferably, if step (vi) is employed, said stamping and coating steps occur simultaneously.

It is sometimes necessary to flux the alloying metals by dipping them in a suitable flux before introducing them into the molten tin. 10%HCl in glycerol is a preferred flux for this purpose but it will be appreciated that other fluxes would have a similar effect.

Preferably the tin is melted using an induction furnace although other types of furnace could also be used. The addition of elements to be alloyed with the tin may be carried out at a temperature in a range of from 250° to 700°C, depending on the melting point of these elements. When phosphorus is the element added it is preferably introduced as a tin-5%phosphorus alloy.

The present invention will be further described by way of example with reference to the drawings, wherein:

Figure 1 shows a plan view of a cast block type (or "clip-on") wheel weight.

Figure 2 shows a side view of a cast block type (or "clip-on") wheel weight.

Figure 3 shows a cross sectional view of a cast block type (or "clip-on") wheel weight attached to the rim of a wheel.

Figure 4 shows a plan view of a mechanically formed flat type (or "adhesive") weight.

Figure 5 shows a side view of a mechanically formed flat type (or "adhesive") weight.

These drawings are only examples of possible weight designs and are not limiting on the scope of the invention. It will be appreciated that many types of design may be used.

Referring to Figures 1 and 2, the wheel weight has a main body (1) formed by casting the tin alloy in a suitable mould. One surface (3) of the main body (1) is shaped so as to provide a close fit with the rim of a wheel. An integral clip (2) is attached to the main body (1) and is also shaped so as to provide a close fit when attached to the rim of a wheel.

Referring to Figure 3, the wheel weight is shown attached to the rim (4) of a wheel. The shape of the surface (3) and integral clip (2) are shown to provide a close fit of the wheel weight to the rim (4).

Referring to Figures 4 and 5, the flat type of weight is mechanically formed from a tin alloy to produce an elongate bar (5) with a series of raised portions (6) of a size dictated by the desired weight for each portion. The raised portions (6) are spaced along the elongate bar (5) by a distance sufficient to enable

separation of the portions using a suitable cutting instrument. The elongate bar (5) is coated, on the underside thereof, with an adhesive tape (7). The adhesive tape (7) is further coated with a protective layer (8) which is removed immediately prior to fixing the weight to the rim of a wheel.

The present invention will be further described with reference to the following Examples which illustrate the production of cast block type wheel weights:

Examples 1 to 5

Alloys were prepared by the combination of the required elements. Tin was first melted using an induction furnace and then the correct amounts of the required elements were added to form an alloy.

The temperature of the tin was raised to about 650°C before the additions of antimony and copper were made.

It was preferable to flux the alloying metals before introducing them into the molten tin. The flux used was 10%HCl in glycerol, but other suitable fluxes would have a similar effect. After the alloying additions had been made the melt was left for several minutes to allow complete alloying to take place. Casting was then carried out from the holding temperature into a heated mould. The cycle time for die-casting was about 5 seconds, depending on the weight size.

Vickers Hardness (Hv) values at a load of 0.5kg were obtained for each example immediately after production and again after artificial accelerated ageing of 13 days at 125°C.

The table below details the alloys of Examples 1 to 5 prepared in this manner.

Alloy Number	Composition (wt %)				Initial Hardness (Hv) (at 0.5kg)	Aged Hardness (Hv) (at 0.5kg)	Melting temperature (°C)
	Pb	Sb	Cu	Sn			
Lead Alloy	97	3	-	-	-	13	270-310
1	-	-	1.5	balance	13.2	10.0	227-267
2	-	4	1.25	balance	19.3	18.7	232-246
3	-	6	1.25	balance	21.8	21.2	234-249
4	-	6	2	balance	23.1	21.8	235-270
5	-	8	2	balance	27.3	25.5	235-262

Claims

1. A wheel weight which comprises an alloy of tin having a melting range with an upper limit of below approximately 320°C and a hardness of at least approximately 6Hv.

2. A wheel weight as claimed in Claim 1 wherein the alloy comprises copper in an amount of from 0.01 to 10wt%, and/or antimony in an amount of from 0.01 to 20wt%, and/or bismuth in an amount of from 0.01 to 65wt%, and/or silver in an amount of from 0.01 to 20wt%, and/or zinc in an amount of from 0.01 to 30wt%, and/or phosphorus in an amount of from 0.001 to 2wt%, and/or indium in an amount of from 0.01 to 15wt%, with a balance of tin.

3. A wheel weight as claimed in Claim 1 or Claim 2 wherein the alloy comprises copper in an amount of from 0.05 to 8wt%, and/or antimony in an amount of from 0.05 to 15wt%, and/or bismuth in an amount of from 0.05 to 20wt%, and/or silver in an amount of from 0.05 to 10wt%, and/or zinc in an amount of from 0.05 to 20wt%, and/or phosphorus in an amount of from 0.001 to 0.5wt%, and/or indium in an amount of from 0.05 to 10wt% with a balance of tin.

4. A wheel weight as claimed in any one of claims 1 to 3 wherein the alloy comprises copper in an amount of from 0.1 to 5wt%, and/or antimony in an amount of from 0.1 to 12wt%, and/or bismuth in an amount of from 0.1 to 10wt%, and/or silver in an amount of from 0.1 to 7wt%, and/or zinc in an amount of from 0.1 to 15wt%, and/or phosphorus in an amount of from 0.001 to 0.1wt%, and/or indium in an amount of from 0.1 to 5wt%, with a balance of tin.

5. A wheel weight as claimed in any one of claims 1 to 4 wherein the alloy comprises copper in an amount of from 0.15 to 4 wt% and/or antimony in an amount of from 0.5 to 10wt%, and/or bismuth in an amount of from 0.5 to 8wt%, and/or silver in an amount of from 0.5 to 5wt%, and/or zinc in an amount of from 0.5 to 10wt%, and/or phosphorus in an amount of from 0.01 to 0.08%, and/or indium in an amount of from 0.5 to 3wt%, with a balance of tin.

6. A wheel weight as claimed in any one of the previous claims which comprises an alloy of tin having a melting or pasty range of from 5 to 50°C.

7. A wheel weight as claimed in any one of the previous claims which comprises an alloy of tin having a melting or pasty range of from 14 to 40°C.

8. A wheel weight as claimed in any one of Claims 1 to 7 in the form of a cast block for clamping to the exterior rim of a wheel.

9. A wheel weights as claimed in Claim 8 having a hardness value in the range of from 9 to 35Hv.

10. A wheel weight as claimed in Claim 8 or Claim 9 wherein the cast block comprises an integral clip.

11. A wheel weight as claimed in Claim 8 or Claim 9 wherein the cast block comprises a removably attached clip.

12. A wheel weight as claimed in Claim 10 or Claim 11 wherein the clip is made of steel.

13. A wheel weight as claimed in any one of Claims 8 to 12 wherein the alloy comprises copper in an amount

of from 0.5 to 4 wt% and tin in an amount of from 96 to 99.5 wt%.

14. A wheel weight as claimed in any one of Claims 8 to 12 wherein the alloy comprises copper in an amount of from 0.5 to 4 wt% and antimony in an amount of from 0.5 to 10 wt% and tin in an amount of from 86 to 99 wt%.

15. A wheel weight as claimed in any one of Claims 1 to 7 in the form of a mechanically formed block with underside adhesive.

16. A wheel weight as claimed in Claim 15 having a hardness value in the range of from 6 to 25Hv.

17. A wheel weight as claimed in Claim 14 or Claim 15 wherein the alloy comprises copper in an amount of from 0.05 to 4 wt% and tin in an amount of from 96 to 99.95 wt%.

18. A wheel weight as claimed in Claim 14 or Claim 15 wherein the alloy comprises antimony in an amount of from 0.5 to 10 wt% and tin in an amount of from 90 to 99.5 wt%.

19. A wheel weight as claimed in Claim 14 or Claim 15 wherein the alloy comprises antimony in an amount of from 0.5 to 10 wt% and copper in an amount of from 0.05 to 4 wt% and tin in an amount of from 86 to 99.45 wt%.

20. A wheel weight as claimed in any one of the preceding Claims wherein the surface is additionally treated and/or coated.

21. A wheel weight as claimed in Claim 20 wherein

the surface is coated with a polymer or plated with chromium or zinc.

22. A process for the production of a wheel weight as claimed in any one of Claims 1 to 9 and 15 to 19 comprising the steps of:
(i) melting a portion of tin,
(ii) adding the required amounts of the elements to be alloyed to the molten tin,
(iii) allowing the melt to stand so that alloying can take place, the time period for this step being dependent upon the temperature,
(iv) casting the alloy by transferring the melt into a mould and either
(v) remelting and die-casting the alloy, or
(vi) extruding the alloy into a wire, stamping it to form the required shape and coating it on one side with adhesive tape.

23. A process as claimed in Claim 22 wherein said coating and stamping steps occur simultaneously.

24. A process as claimed in Claim 20 or 21 wherein the tin is melted using an induction furnace.

25. A process as claimed in any one of Claims 22 to 24 wherein step (ii) is carried out at a temperature in the range of from 250° to 700°C.

26. A process as claimed in any one of Claims 22 to 25 wherein the phosphorus component, if added, is added as a tin-5%phosphorus master alloy.

27. Process as claimed in any one of Claims 22 to 26 wherein the elements to be alloyed with the tin are fluxed before introducing them into the molten tin.

28. A process as claimed in Claim 27 wherein the flux is 10% HCl in glycerol.

29. Use of an alloy of tin having a melting range with an upper limit of below 320°C and a hardness of at least approximately 6Hv in the manufacture of a wheel weight.

30. A wheel assembly for an automobile which comprises one or more wheel weights as claimed in any one of claims 1 to 21.

FIG. 1.

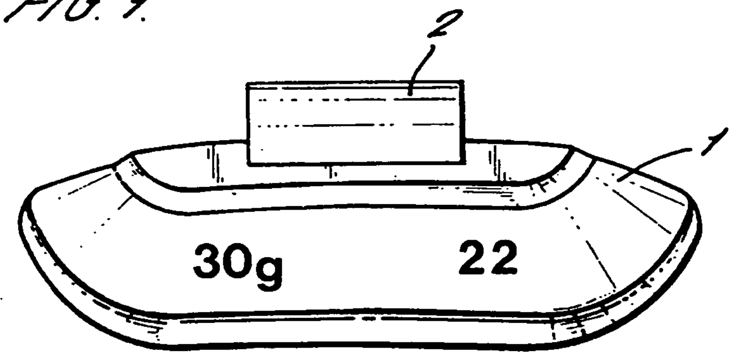


FIG. 2.

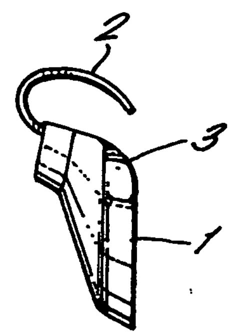


FIG. 3.

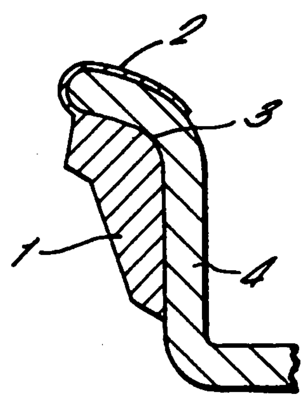


FIG. 4.

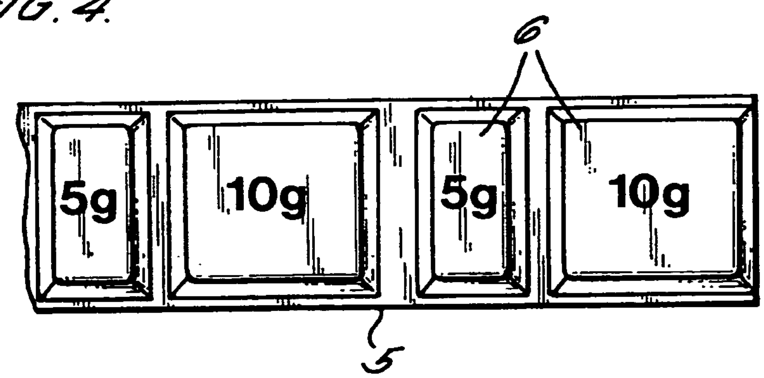
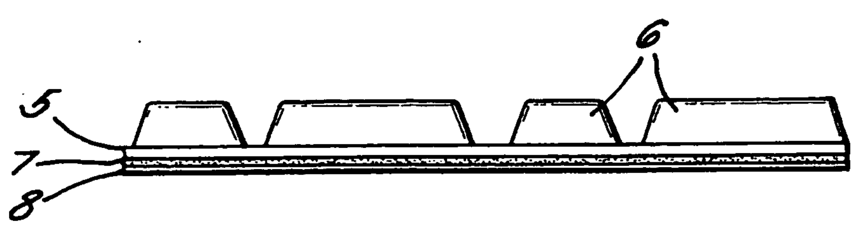


FIG. 5.



INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 99/01282

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 C22C13/00 F16F15/32 F16F15/34

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 C22C F16F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 350 220 A (ATWELL JR ROBERT J) 27 September 1994 see column 2, line 29 - line 31	1-30
A	US 5 500 183 A (NOORDEGRAAF JAN ET AL) 19 March 1996 see column 1, line 12 - line 14; claim 1; table 1	1-30
A	DD 142 893 A (FLECHTNER JOACHIM;HEILMANN KARL; PAETZOLD VOLKER; STADLER HELMUT) 16 July 1980 see page 3, line 8 - line 9	1-30

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

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Date of the actual completion of the international search	Date of mailing of the international search report
8 July 1999	27/07/1999

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 99/01282

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 096, no. 010, 31 October 1996 & JP 08 144038 A (HITACHI POWDERED METALS CO LTD), 4 June 1996 see abstract	1-30
A	EP 0 771 967 A (BRIDGESTONE CORP) 7 May 1997 see column 3, line 31 - line 32	1-30

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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PCT/GB 99/01282

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			EP	0655604	A	31-05-1995
			FI	945484	A	27-05-1995
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